Report for 2004NV65B: Small Scale Variability of Soil Ped Hydraulic Properties: Potential Impact on Soil Recharge and Ecosystems

Publications

- Articles in Refereed Scientific Journals:
    - Meadows, D.G., M.H. Young, E.V. McDonald. 2005. A laboratory method for determining the unsaturated hydraulic properties of soil peds. Soil Sci. Soc. Am. J. 69:807-815.
    - Meadows, D.G., M.H. Young, E.V. McDonald. 2006. Influence of Surface Age on Hydraulic Properties and Infiltration in Desert Pavement Environments. Catena. Submitted.
- Conference Proceedings:
    - Meadows, D.G., M.H. Young, E.V. McDonald. 2005. The mechanism of infiltration on desert pavements as a function of surface age. Soil Science Society of America 69th Annual Meeting, Salt Lake City, UT, Nov. 6-10, 2005.
    - Meadows, D.G., M.H. Young, E.V. McDonald. 2005. Hydraulic property determination of vesiculated soil peds in desert pavement environments. W-188 Soil Physics Research Group Meeting. Las Vegas, NV, Jan. 3-5, 2005.
    - Meadows, D.G., M.H. Young, E.V. McDonald. 2004. Hydraulic properties of individual soil peds, Mojave Desert, CA. Soil Science Society of America 68th Annual Meeting, Seattle, WA, Oct. 31-Nov. 4, 2004.
    - Young, M.H., D.G. Meadows, D. Gimenez, R.J. Heck, T.R. Elliot. 2004. Dynamic behavior of pore morphology using CT scanning preliminary results. Soil Science Society of America 68th Annual Meeting, Seattle, WA, Oct. 31-Nov. 4, 2004.
    - Prim, P.S., D.G. Meadows, M.H. Young. 2004. Determination of interped flow and surface sealing through infiltration experiments on a 100 kA desert pavement. Geological Society of America Annual Meeting, Denver, CO, Nov. 7-10, 2004.

Report Follows

Synopsis

Final Report

Problem and research objectives

Spatial variability of soil properties has significant impacts on desert ecosystems that are highly water limited. Coupling that observation with the fact that the southwestern United States has been experiencing significant drought conditions for the past several years, we are left with the need to better understand how water moves through the upper soil surface, into the deeper horizons, and potentially downward to the water table. Many soil surfaces in the desert southwestern United States are covered with highly structured desert pavement environments. The evolution of the hydraulic properties that results from pedologic development over time has implications for the mechanisms, frequency, and depth of recharge events, and how those events could influence plant ecosystems, deeper soil recharge, and potential recharge to groundwater supplies.

Methodology

In this study, we compared the hydraulic properties derived from tension infiltrometer experiments conducted in the field, with the average hydraulic properties of individual soil peds that comprised the area underneath the infiltrometer. This approach facilitated investigation of the interped cracks that separated the individual soil peds on the soil surface because the field infiltrometer method samples ped and interped areas, and the laboratory method samples only the peds themselves. Therefore, the method provides a means to quantify the potential water flow through these preferential flow pathways. The laboratory method for determining the hydraulic properties of individual soil peds is novel and is based on traditional evaporation experiments. Experiments were conducted on three different-aged desert pavement surfaces in the Mojave Desert.

We also conducted experiments where dyed water was applied to four different-aged surfaces under saturated conditions. Following the experiments, the soil was excavated in 2-cm depth increments. Digital images were taken at each depth. The images were then analyzed in a GIS program to calculate the area of dye-stained soil.

Principal findings and significance

We developed a new laboratory method for determining the hydraulic properties of individual soil peds (Meadows et al., 2005). We show:

- K_s and α are significantly higher for the peds on the younger Qf5 surface, most likely a result of reduced pedologic development compared to the older Qf3 and Qf2 surfaces.
- Although the Qf2 and Qf5 surfaces are approximately similar in age, the Qf2 exhibits properties more similar to an older surface (i.e., a Qf3). This may be explained by the fact that the original pavement mantling the Qf2 deposit was stripped away from erosion

and a new pavement re-formed on the site. Thus, the present, re-formed pavement may have been formed on remnant structure from the original pavement.

- Large interped variability exists in the hydraulic properties at the scale that we sampled (tens of cm).
- The oldest surface exhibited the largest variability in hydraulic properties, particularly in K_s. The reason for this difference in variability is uncertain, but probably relates to the disparate lengths of time that the peds have existed at the surface and thus exposed to shrink-swell activity and other pedogenic processes.
- Infiltration into the soil is dominated by the interped cracks on the older surfaces when conditions are near saturation. These interped cracks are preferential flow paths and may increase deep percolation and potential recharge.
- On the young, unstructured surface, water moves rapidly through the soil matrix. Thus, a transition in the primary mechanism of infiltration occurs from a matrix dominated to a preferential flow dominated system.
- The steady-state infiltration rates of the bulk soil are fairly constant once peds are developed (≥10 ka). However, the fact that the steady-state infiltration rates are constant, yet the ped conductivity decreases from the Qf5, may indicate an increase in preferential flow to compensate for the decrease in ped conductivity.
- On well-developed pavements, infiltration appears to occur along ped faces. Water then diffuses toward the ped interiors.
- The total crack length is greater for the Qf3 and Qf2 surfaces. The increase in the preferential flow paths may also explain the constant steady-state infiltration rates.
- The 20 cm diameter tension disc infiltrometer is capable of capturing the ped variability on the surface that exhibits the most ped-to-ped variability (i.e., Qf3).

Information Transfer Activities

Papers:

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Presentations:

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Student Support

This grant largely funded the research endeavors (time, instruments and travel) during completion of Darren Meadows' Ph.D. degree. In addition, the grant funded Pamela Prim, an undergraduate student at University of Nevada Las Vegas (UNLV), Department of Geosciences, who helped with the laboratory and field work. Pamela presented a poster at the Geological Society of America meeting in 2004. Another UNLV student who is working on his M.S. degree, Todd Arrowood, was also funded on this project to help with laboratory and field experiments.